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ABSTRACT

When the public school system of Ontario, Canada, began offering an all-female computer science course for girls in grade 11, female enrollment in computer science increased to approximately 40%. This increased enrollment level has been maintained for 3 years. The new course's effects on girls' attitudes were examined in a survey of 184 grade 11 students enrolled in the Ontario computer science course. The sample included 45 girls enrolled in all-female sections of the course and 114 boys and 25 girls enrolled in mixed-gender sections of the course. Girls from the all-female classes and boys reported similar levels of perceived teacher support and similar levels of confidence and intrinsic value, whereas girls from the mixed-gender classes reported less perceived support, lacked the confidence of their peers, and did not enjoy working with computers as much as boys or the girls from the all-female sections of the course did. A successful summer camp program to increase elementary students' understanding of and skills in science and engineering was described along with efforts to promote high technology for girls. The strategy included building a consensus with a local high-technology firm to develop a proactive enrollment strategy and positive learning environment and talking with female students to diminish sex stereotypes. (Contains 5 figures and 8 references.) (MN)

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Research on Young Women in Computer Science: Promoting High Technology for Girls

Gail Crombie

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RESEARCH ON YOUNG WOMEN IN COMPUTER SCIENCE: PROMOTING HIGH TECHNOLOGY FOR GIRLS

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Invited presentation made at the annual meeting of the
Professional Engineers of Ontario, Women in Engineering Advisory Committee (WEAC)
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Theme: Opening Doors - Opportunities for Tomorrow for Young Girls

ABSTRACT

The low percentage of girls who enroll in computer science and other high technology programs is a concern to teachers, guidance counselors, and the high technology industry. As computers continue to become more pervasive in our society, low rates of enrollment in high technology programs by girls will have negative consequences for their future career opportunities. Results obtained from two successful programs designed to increase female interest and enrollment in academic courses related to high technology and engineering are examined. The importance of developing strategies designed to create positive learning experiences for girls is highlighted as part of an analysis of the characteristics of successful interventions designed to promote the participation of girls in academic programs that are traditionally male dominated.

INTRODUCTION

A major concern among teachers, guidance counselors, and the high technology industry is the low percentage of females who enroll in computer science and other high technology courses at the high school, college, and university levels, as well as the under-representation of women in high technology related careers, such as computer engineering and programming. The issue of females' lower participation and interest in this field is not a new phenomenon and a substantial amount of research has been conducted in this area. Over the last ten years, a number of solutions have been proposed to address this gender gap.

Today I will be providing some interesting results from the research which we have been conducting on one of these proposed solutions, as well I will present information about the actual process which was involved in implementing this type of solution and will conclude with suggestions for multi-faceted and age-related programs to increase the interest and participation of females in the fields of computer science and high technology.

Gender differences in enrollment in computer science courses have been present since the 1980s, when the personal computer entered our schools, work places, and homes, and these gender differences are still present today. Gender differences in enrollment are larger for computer programming courses than for computer application courses, and become more pronounced at higher levels of education (Comber, Colley, Hargreaves, & Dorn, 1997; Hess & Miura, 1985; Stumphf & Stanley, 1997). The latest Statistics Canada figures indicate that females are only 15 to 20 percent of students enrolled in computer science and electrical engineering at the university level.

As the computer continues to become more pervasive in our society, computer literacy is emerging as a new filter, not only for specific careers such as computer engineering, but also for career options in general. In many respects, computer knowledge will be an additional filter over and above the effects of mathematics for future career options. It is important that we continue to open doors to promote girls' enrollment in computer science courses. To do this, it is necessary to understand the various

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reasons for this gender gap in enrollment.

Computers are still perceived as being a male domain by both girls and boys. These perceptions are developed early. More boys play with computer games, and the games are clearly designed to appeal to boys. One of the effects of this is that boys gain more experience with computers early on and these experiences are positive ones. This gender gap in experience with computers is a critical factor. Researchers have found that positive computer experiences are a predictor of positive attitudes, and positive attitudes are the best predictor of future behavior for computer-related activities (Levine & Donitsa-Schmidt, 1998). Thus, to open doors for girls, two basic strategies are of prime importance: (1) strategies to increase girls' enrollment and (2) strategies to create positive learning experiences for girls.

We have been very fortunate to be involved with a high school, in which an all-female Grade 11 computer science class has been offered for the last three years. This is one of the few schools in the Ontario public school system which has experimented with this approach, and this program has obtained some interesting results.

Before the all-female class was offered, approximately 10 to 15 percent of the adolescents who signed up for the course were girls. That is to say, in a computer lab with 30 students, there would be only 3 or 4 girls. When they began offering the all-female class, the number of girls who enrolled increased to approximately 40 percent, which is a substantial improvement. This increase in the number of girls has been maintained over the last three years, and they obtained similar results again this spring when enrollment choices were made for next year. Thus, solely from an enrollment standpoint, the all-female class clearly has been a success, but there have also been some positive effects on girls' attitudes and future intentions. These effects were assessed by a questionnaire which we administered to the students in all the Grade 11 computer science courses at this high school.

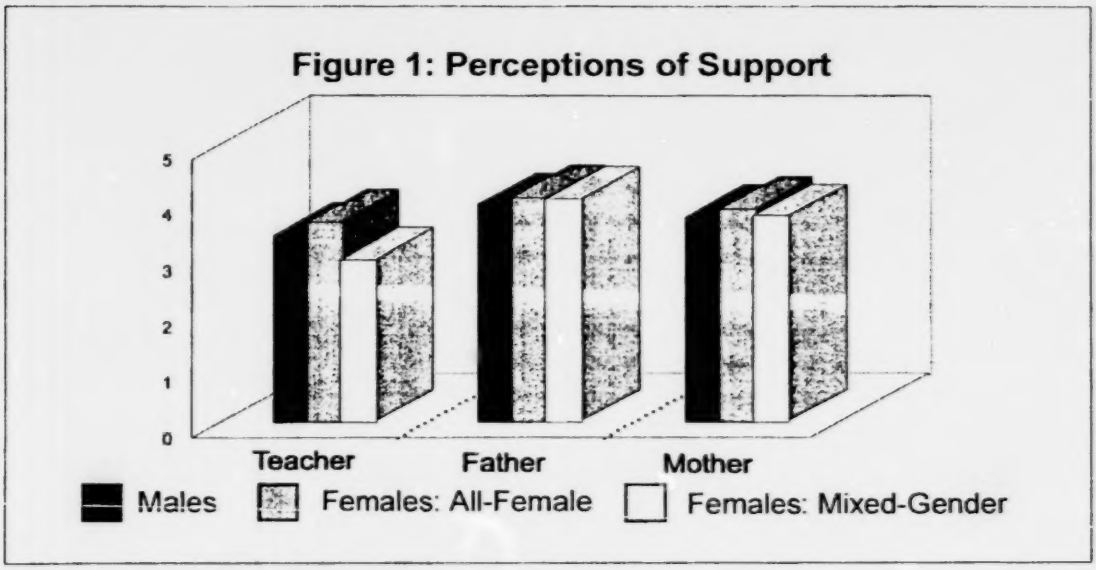
METHODOLOGY

The questionnaire was administered to 184 Grade 11 computer science students in the spring of 1997 and in the spring of 1998. Forty-five girls were enrolled in the all-female sections of the course, and 114 boys and 25 girls were enrolled in the mixed-gender sections of the course. A total of nine 12-item scales were administered to the students: three measures of students' perceived support; that is, their perceived support from their teacher, father, and mother for them as learners of computer science; four attitude measures of students' self-perceptions of confidence in, usefulness, intrinsic value, and gender stereotyping of computer science and computer-related activities. These measures were developed from scales originally used by Fennema and Sherman (1976) to measure attitudes towards mathematics. Other researchers have used these scales with similar modifications (Campbell, 1992). For future intentions, there were two measures, one for future academic intentions and the other for future career intentions in the field of high technology. A detailed analysis of the results obtained in the spring of 1997 is presented in Crombie and Armstrong (1999).

RESULTS

To examine differences in computer-related attitudes and future intentions, one-way ANOVAs were conducted for the independent variable of group classification (girls from the all-female classes, girls from the mixed-gender classes, and boys from the mixed-gender classes) on each of the nine measures.

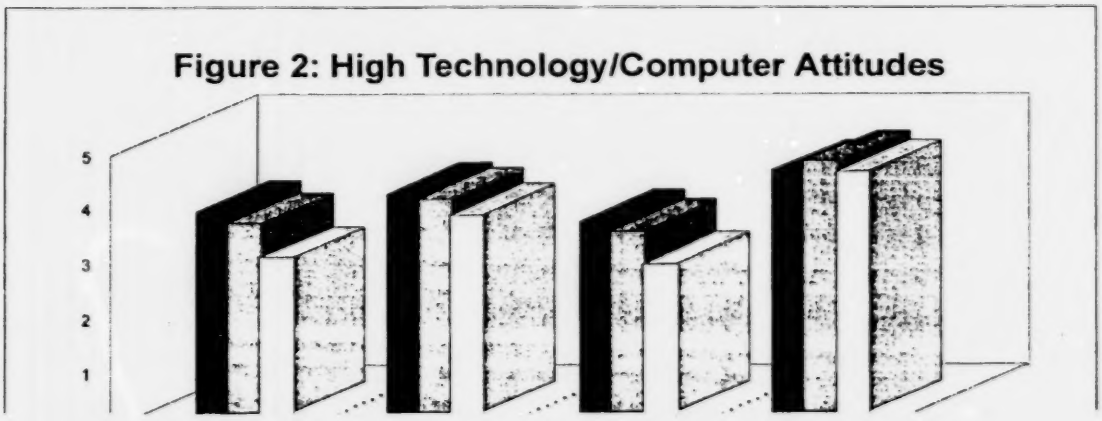
In terms of the students' perceptions of support for their interest in computers, we found a significant group difference for perceived teacher support: girls from the all-female classes and boys reported similar levels of perceived teacher support, whereas girls from the mixed-gender classes reported less perceived support. This result is interesting because the same teachers teach both the all-female and mixed-gender classes. Perceived support from teachers and parents are presented in Figure 1.

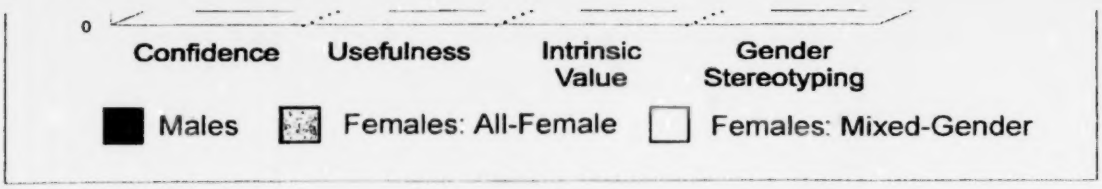


There were no significant differences in perceived support from fathers or mothers, which is important to note, because it could be argued that one of the contributing factors to gender differences in this area is that parents are more supportive of the computer-related interests of their sons than of their daughters. However, this was not found for this group of students who had selected to enroll in an elective Grade 11 computer science course. This lack of group differences on these two measures provides some support for the suggestion that the differences which we have found on the other measures are not a product of pre-existing or systematic differences among the groups.

In terms of the attitude measures, there were significant group differences for both confidence and intrinsic value, but not for usefulness and gender stereotyping (see Figure 2). The group differences which we found mirror the differences found for perceived teacher support: girls from the all-female classes and boys reported similar levels of confidence and intrinsic value and these levels are higher than those reported by girls from the mixed-gender classes.

Another way to interpret these results is that girls from the mixed-gender classes share the views of their peers towards the usefulness of computers and the appropriateness of computers for girls (higher scores indicate support for the view that computer-related activities are appropriate for both genders, low scores represent the view that computers are more appropriate for boys), but they lack the confidence of their peers and do not enjoy working with computers as much.

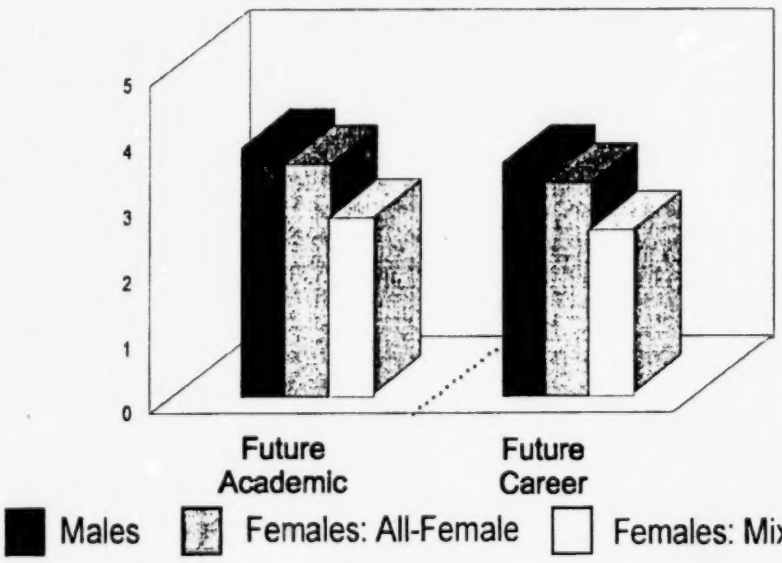




These group differences translate into differences in future intentions: as was the case with teacher support, confidence, and intrinsic value, girls from the all-female classes and boys report similar levels on these measures, whereas girls from the mixed-gender classes are less inclined to take more computer science courses or pursue occupations in this field (see Figure 3).

To understand the relations between perceived support and attitudes, and to understand how these factors can influence future intentions, we conducted path analyses using standardized column-wise multiple regression equation procedures. The significant predictors for girls' attitudes and future intentions are presented in Figure 4. Teacher support is an important predictor of girls' confidence in their ability in computer science, their intrinsic valuing of computer science, and perceived appropriateness of computer science for girls. Father and mother support are somewhat predictive. Of the attitude measures, for girls, the strongest predictor of future intentions is their intrinsic valuing of computer science.

Figure 3: Future Intentions



For boys, there are some similarities and differences in the pattern of results (see Figure 5). The predictive power of teacher support is lower for boys, relative to the results we found for girls. However, father support is quite predictive of boys' perceptions of the usefulness of computer science and computer-related activities. Furthermore, it is usefulness (i.e., utility value), rather than intrinsic value, which is the strongest predictor of boys' future intentions.

DISCUSSION

The All-Female Computer Science Class

The implementation of all-female computer science classes can be considered, in this case, to be a successful program, not only for improving enrollment from 10 to 40 percent for girls, but also for improving girls' attitudes and future intentions for computer-related activities.

These improvements can be attributed to a learning environment which promotes positive attitudes towards computers in girls. Our results indicate that the all-female class is a more positive learning environment for girls, an environment where their teacher was perceived as being more supportive of their interest in computer science, an environment that allowed them to develop greater confidence in their ability to work with computers and to find more intrinsic value in working with computers than their female peers in the mixed-gender classes. In addition to increasing enrollment and producing more positive attitudes, the all-female class also improved girls' future intentions to continue in this field.

Figure 4: Path Analysis for Females

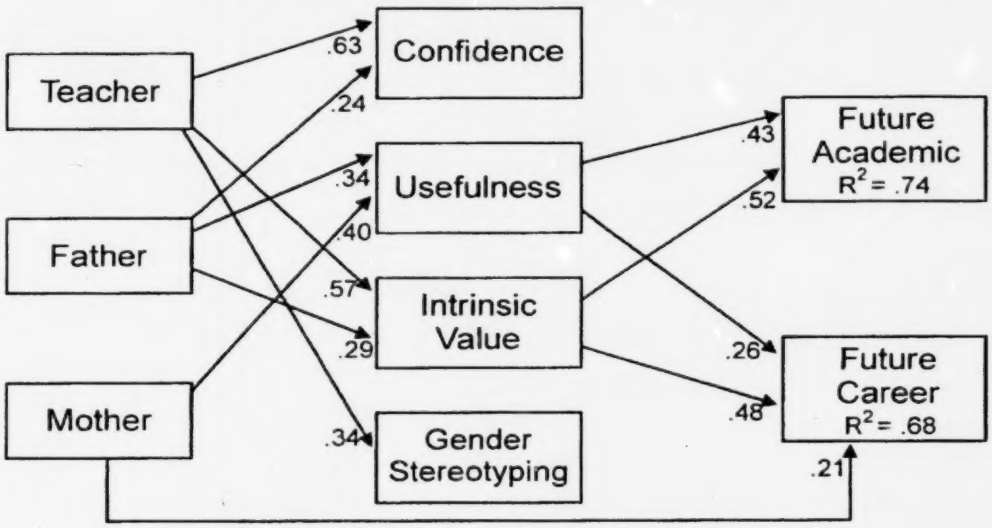
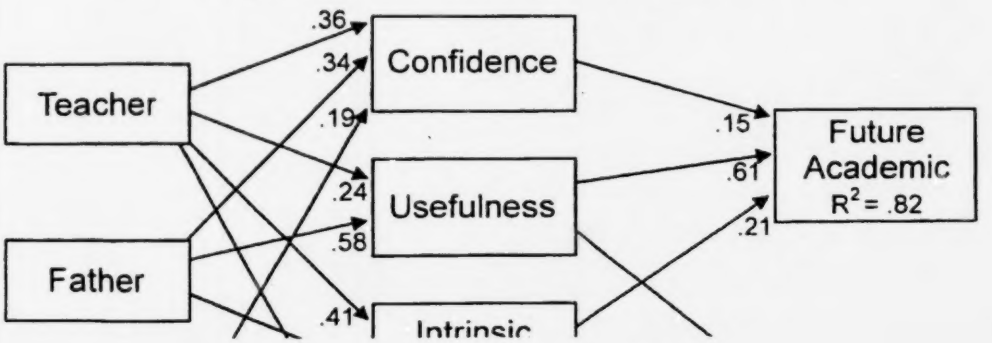
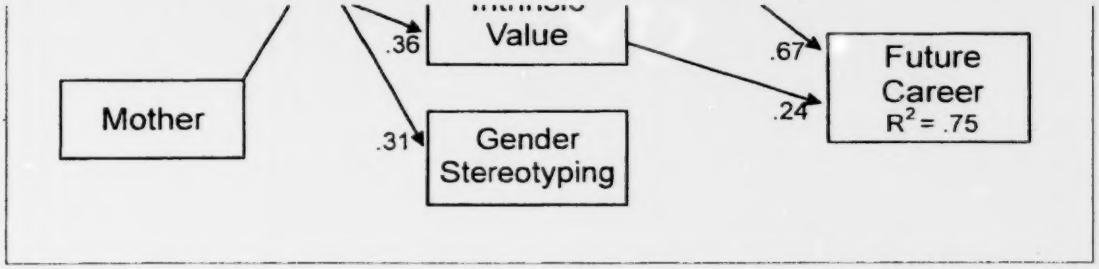


Figure 5: Path Analyses for Males





In addition to these results, there is anecdotal evidence to support the position that the all-female class is having a positive effect. When the all-female class was offered in the second year, 41 out of 43 girls stated a preference for the all-female class. In comments made, some of the girls stated that they preferred being in a classroom without, to use their phraseology, the "know-it-all boys".

The Worlds Unbound Summer Camp Program

In our study, the use of an all-female classroom environment produced more positive attitudes towards computer science and computer-related activities than were found for girls in mixed-gender classrooms. There are other approaches that can be used to achieve the objectives of increasing girls' interest and participation in computer science and engineering. To indicate the potential diversity in approaches used and to emphasize certain commonalities, I will outline briefly the "Worlds Unbound" summer camp program offered at the University of New Brunswick for students from grades 5 to 8 (Frize, 1998).

This summer camp program was designed to increase young students' understanding of science and engineering and to improve their confidence and skills in these areas. This program had a somewhat different approach, but also focussed on the two aspects of (1) a specific enrollment policy and (2) specific activities designed to reflect the interests of both genders. Their enrollment policy was to admit an equal number of girls and boys. If there was an excess of boys, the boys were placed on a waiting list. If one of the boys on the waiting list found a girl to join the program, he was admitted preferentially over the others on the list. According to the program organizers, this allowed boys and their parents to be part of the solution, that is, to attract girls to the program. After the first year the program was known in the area as being a positive experience for girls and this rule rarely had to be exercised in the following years, in that there generally was a spontaneous admission of 50 percent girls. The program organizers, however, acknowledged that this ideal situation may change in the future and thus they suggested that their enrollment policy should remain in place to deal with any future downturns in applications from girls.

This program is an indication of the diversity of recruitment approaches which can achieve the objectives of increasing girls' interest and participation and thus resulting in a critical mass of girls in these programs. It is clear that there is more than one approach which will be effective and that specific proactive strategies (e.g., Gilbride, Kennedy, Waalen, & Zywno, 1999) and enrollment policies are being employed.

Three Key Objectives to Accomplish

In promoting girls' interest and participation in computer science courses, there appears to be three major objectives which need to be met: (1) providing information - (a) information to counter gender-related stereotypes about computer science, and (b) information about the various educational and career paths which girls can pursue in high technology fields; (2) increasing the enrollment of girls; and (3) providing girls with positive learning experiences that build positive attitudes towards computer science.

Of these three objectives, the third objective of developing positive attitudes in female students is probably the most important in terms of achieving the long-term goals of increased female presence in these fields, however it will be difficult to achieve the third objective without having previously accomplished the first two.

If we take the example of a female high school student who is making her course selections for next year, if she has very stereotyped attitudes about using computers, it is unlikely that she will sign up for a course in computer programming. Therefore, an important first step towards developing her potential in this area is to provide the necessary information which demonstrates that computer science is an appropriate female activity and viable career choice for women.

If she has been exposed to information to diminish her stereotypes about computer science then she may begin to think about taking an elective course in computer science. If the course is only available in a format with which she is uncomfortable, then it is still unlikely that she will sign up for the computer science course. Therefore, it is important to provide courses and other learning opportunities that are presented in a format which will encourage her participation. The all-female computer science class is a good example of this.

If her stereotypes are diminished and she signs up for the course, but does not have the right kind of experiences which enable her to develop positive attitudes towards working with computers, then it is unlikely that she will take more advanced courses in the future. It is for this reason that developing positive attitudes is the key to obtaining long term increases in the rate of female involvement in computer science and related fields. Positive academic experiences produce more positive attitudes towards computer science and it is these attitudes that will influence her future choices.

In addition to these three objectives, there is also the issue of age appropriate programs, which target girls early and at different transition points: (1) at the pre-high school level, such as the UNB summer camp program; (2) at the high school level, when elective courses in computer science become an option; (3) at the transition to post-secondary education; and (4) at the transition to a career.

The Implementation of a Successful Program

The second major component of today's presentation are the steps and characteristics of a successful program, in particular the one program on which our results are based. A successful program will be designed to achieve the three objectives of diminishing stereotypes, increasing girls' enrollment, and providing the necessary learning experiences to promote positive attitudes towards computer science and related high technology fields.

The following are the experiences of one computer science teacher who has implemented and maintained a program of offering an all-female computer science class in our Ontario school system for four years. I will outline the steps he took and the doors he opened.

First - Building a Consensus

(Proactive Enrollment Strategy & Positive Learning Environment)

The high school has a partnership with Nortel Networks and the computer science teacher was setting up a virtual tour project with one of the members of the Education Interaction Department of Nortel Networks. In their discussions, the issues of low enrollment in computer science courses at the high school level and particularly the low enrollment of girls were discussed. One result of these discussions was that the computer science teacher wrote a report for Nortel Networks which (1) focussed on why an all-female class should be offered and (2) outlined approaches for this class

which would take into consideration girls' interests, issues, and learning styles. With this report, as well as encouragement from Nortel Networks, the computer science teacher was able to build consensus within his school and get the support of his principal. Although the support was there, the teacher had to be the person predominantly responsible for setting up the program.

Second - Talking with Female Students

(Diminishing Stereotypes)

The teacher first gave a survey to all the girls in Grade 9 about their attitudes and stereotypes concerning computers and computer science. He then followed up with a discussion session with all the Grade 9 girls, through their physical education classes, to inform them about the all-girls program the following year, to outline its characteristics, and to discuss the survey with them, which for the teacher was an opportunity to diminish myths and stereotypes about computer science and high technology. From these discussions, there was subsequently sufficient girls, who enrolled and who preferred the all-girl format, to start the first class.

In the second year of the program, they advertised the all-girl format via an informational flyer handed out in all math classes during the weeks before students made their course enrollment decisions for the following academic year. They subsequently contacted the girls who had enrolled concerning their preferences for class format. In the third and fourth years, word of mouth has been sufficient to maintain an enrollment level of 40 percent girls.

This is one excellent example of a successful program within our high school system which included

(1) providing information to counter stereotypes, (2) a specific recruitment strategy for girls, and (3) positive learning experiences which took into consideration the interests of girls.

I would like to conclude by giving a major acknowledgment to the commitment and determination of one high school teacher.

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